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Digital Sustainability for Energy-Efficient Behaviours: A User Representation and Touchpoint Model

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Abstract
In response to climate change, nations have been tasked with reducing energy consumption and lessening their carbon footprint through targeted actions. While digital technologies can support this goal, our understanding of energy practices in a private household context remains nascent. This challenge is amplified by the 'invisible' nature of users' interaction with energy systems and the impact of unconscious habits. Our objective is to explore how touchpoints embedded in digital sustainability platforms shape energy-efficiency behaviours among users. Building on data from semi-structured interviews and a two-hour co-creation workshop with 25 energy experts in the ECO2 project, we first identify three user representations of relevance to such platforms: *energy-unaware*, *living in denial*, and *energy-aware and active*. Our findings suggest that 'static' user representations (based on user demographics and average consumption) are giving way to socio-cognitive representations that follow users' journeys in energy efficiency. We then develop a set of design principles to promote sustainable energy behaviours through digital sustainability platforms across *user-owned*, *social/external*, *brand-owned*, and *partner-owned* touchpoints. An analysis of user feedback from the ECO2 project shows support for our design principles across users' journeys. Of 62 respondents covering all three representations, 76% of them intended to "implement changes in terms of energy consumption and energy efficiency".

Keywords Digital sustainability · Energy efficiency · Multimethod study · Green IS · User journeys · Touchpoints · User representations

1 Introduction

Under the Paris Climate Agreement, nations across the world have been tasked with promoting sustainable energy initiatives that help fight climate change and limit global warming (Meinshausen et al., 2022). Several long-term policy measures have been proposed to achieve environmental targets including infrastructural investments in renewable energy (Wörner et al., 2022) and the decarbonisation of business processes (Chatterjee et al., 2022). A more immediate measure, however, focuses on behavioural change initiatives for promoting user transitions towards sustainable energy consumption in private households (El Idrissi & Corbett, 2016; Sim et al., 2023; Wörner et al., 2022). This can centre on two approaches: energy conservation and energy efficiency. Energy conservation aims to lower energy inputs by making sacrifices in comfort, for instance, adjusting the thermostat in living areas to 15–18 °C (SEAI, 2024). In contrast, energy-efficient behaviours aim to lower energy inputs while maintaining similar outputs (Loock et al., 2013). This includes actions such as investing in a more efficient boiler, reserving the use of power-intensive appliances for times when there is lower energy demand on power stations, and unplugging electronic devices when not required. Our study focuses on the latter approach by investigating the promotion of energy efficiency.

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To date, behavioural change activities can broadly be categorised as 'static' public awareness campaigns that aim to promote energy efficiency through sharing tips on sustainable energy consumption (Loock et al., 2013). The effectiveness of such interventions is questionable, however, with research suggesting that many fail to achieve the targeted user behaviours. This is due to the limitations of standardised one-way communication, the simplification of complex ideas, and the lack of tailoring to specific household needs (cf. Jha & Verma, 2024; Shittu, 2019; van den Broek et al., 2019). Recent studies have therefore turned attention towards a more interactive approach to behavioural change using technologies such as gamification (Chamaret et al., 2023), social media (Jha & Verma, 2023; Jha & Verma, 2024), and peer-to-peer trading platforms (Wörner et al., 2022) to change household energy practices.

Digital Sustainability is a bourgeoning research stream that explores how Information Systems (IS) and digital artefacts can proactively support the adoption of sustainable behaviours and practices (Corbett et al., 2023; Kotlarsky et al., 2023; Pan et al., 2022). This builds on the established research domain of green IS which primarily focuses on physical IS artefacts for environmental sustainability outcomes (El Idrissi & Corbett, 2016; Gholami et al., 2016; Watson et al., 2010). To date, literature in this area has focused on organisational levels of analysis, investigating topics such as eco-efficient work practices (Alraja et al., 2022; Degirmenci & Recker, 2023; Leidner et al., 2022), the development of environmental Information Technology (IT) strategies (Loeser et al., 2017), and systems for environmental sustainability transformations (Seidel et al., 2018; Zampou et al., 2022). In contrast, our knowledge of sustainable energy practices at the individual level of private households is comparatively scarce (Kotlarsky et al., 2023; Loock et al., 2013; Wörner et al., 2022; Wunderlich et al., 2019). This is despite the significant contribution of private households to final energy consumption (around 27% in Europe) and carbon emissions (Eurostat, 2023) which has more recently been amplified by the increased adoption of remote working practices (Jiang et al., 2021).

Digital sustainability platforms can support private household users in understanding the impact of their existing energy consumption behaviours to guide them towards more sustainable behaviours (Sim et al., 2023). This centres on the delivery of data, information, and knowledge to users through diverse media formats. Despite the potential of digital platforms for supporting energy-efficient behaviours, our understanding of user needs in a private household context remains nascent. This is an important area of further study as a 'one size fits all' approach to platform design is unlikely to appeal to diverse user groups (McCarthy et al., 2022).

Motivated by the background above, our paper seeks to address the following research question: *How do the touchpoints embedded within digital sustainability platforms interact to influence energy-efficient behaviours among different user representations?* Our study focuses on the context of individual private households rather than collective settings such as organisations and energy communities. We also limit our conversation to the antecedents of behavioural change for energy-efficient practices. Data in the study was gathered through a 36-month EU project called ECO2 which sought to design a digital platform for users to increase their energy efficiency. We first examine user representations based on qualitative data gathered through 11 semi-structured interviews and a two-hour online co-creation workshop with 14 energy experts. This included actors from municipalities and public authorities that are tasked with promoting sustainable energy consumption behaviours among residential users, as well as government-created energy advisory programs at national and regional levels. Their responses were captured as a set of design principles that informed the development of a digital sustainability platform called ACT4ECO. We then analyse survey data from 62 users to evaluate this digital sustainability platform and the impact of design choices on user behaviour across different touchpoints.

To understand the needs of different user representations in energy experts' accounts, we adopt a socio-cognitive perspective (Bandura, 1986, 2001) which distinguishes three important antecedents of user behaviours: *self-efficacy, outcome expectancy*, and *social modelling*. We then move to the question of how to design digital interventions that promote sustainable energy consumption behaviours among users over time, leveraging the touchpoint typology of Lemon and Verhoef (2016). We posit that touchpoints in the users' evolving journeys can help identify features for supporting different stages of users' interactions with the platform.

Our study makes several contributions which will be of interest to IS scholarship and practice. Firstly, we inductively reveal three primary user representations that digital platforms should target when promoting sustainable energy behaviours: *energy-unaware users, energy users living in denial*, and *energy-aware and active users*. Empirical data is analysed to gain a deeper understanding of these dynamic user representations and the socio-cognitive factors that shape sustainable energy consumption in private households. This informed the development of design principles that can help improve the impact of digital sustainability platforms over time. Based on our findings, we map these design principles to Lemon and Verhoef's (2016) touchpoint typology and discuss how intentionally shaping each touchpoint is imperative for behavioural change and maintaining user engagement.

The remainder of this paper is structured as follows: Section 2 provides the background to our study by reviewing the literature on energy-efficiency promotion through digital platforms, Social Cognitive Theory, and user representations. Section 3 then provides an overview of our methodology, while the findings from the user representations and design principles are presented in Section 4. Further, Section 5 presents the results of the users' evaluations of the ACT4ECO platform. Section 6 discusses theoretical and practical implications as well as the limitations of our study, while section 7 brings the paper to a close with a conclusion.

2 Background

2.1 Sustainable Energy Behaviours and Digital Platforms

Digital sustainability refers to the design, development, and use of digital artefacts (e.g., data analytics, IoT, artificial intelligence) and digital resources (e.g., blockchain, cloud computing) to achieve environmentally sustainable objectives (Corbett et al., 2023; Kotlarsky et al., 2023; Pan et al., 2022; Watson et al., 2010). This builds on the established discourse on green IS which focuses on how technology can help improve the flow and management of information to change user behaviours and practices (Sarkis et al., 2013), such as carbon footprint tracking in organisations (Corbett, 2013; Leidner et al., 2022), or energy management in the household (Loock et al., 2013; Wörner et al., 2022; Sim et al., 2023). Prior studies in this space have investigated how technologies such as decision-support systems (Seidel et al., 2018), discussion forums, and dashboards (Degirmenci & Recker, 2023) can support the objective of acquiring knowledge on *"how and why to reduce waste by operating devices more efficiently",* providing hints towards their larger environmental impact (cf. Spagnolli et al., 2011, pg. 40).

Of interest to our study is the application of digital technologies to deliver data, information, and knowledge on energy-efficient behaviours. Sustainable energy interventions to date have typically taken a multi-channel approach - regularly exposing users to the same or similar information across different communication mediums (Loock et al., 2013). Real-time energy consumption feedback has been found to support energy consumption reduction - at least short-term (Burchell et al., 2015). Sim et al. (2023) found that information provided through smart meter technology can promote residential energy-saving behaviours by disconfirming prior beliefs about energy consumption. They also find that the relationship is moderated by a user's energy-saving motivations and concern for climate change. This is consistent with findings from Wunderlich et al. (2019) who assert that smart meter technology adoption is shaped by motivational factors such as a user's interest in pro-environmental behaviours and their perceived control. Loock et al. (2013) furthermore found that green IS can promote energy-efficient behaviours in the household through user goal setting and feedback. Feedback on goal attainment was shown to moderate the effect of 'default goals' on the user's goal choice for energy-efficient behaviours (Loock et al., 2013).

However, inconsistent results have been achieved when evaluating economic, environmental, motivational drivers (i.e., pledges and goal setting), social norms, changing user habits, or the environment in which energy behaviours take place (Degirmenci & Recker, 2023; Loock et al., 2013; Shittu, 2019; van den Broek et al., 2019). In addition to these challenges, sustainable energy interventions face constraints in reaching different households and sustaining interest across longer periods (Vassileva & Campillo, 2014). Rather than aiming to promote completely new behaviours, it has been suggested that interventions that consider habit discontinuity may be more effective (Degirmenci & Recker, 2023; van den Broek et al., 2019). This can be achieved using 'digital nudges' to alter 'bad habits' or reinforce existing energy-efficient consumption behaviours. For instance, Beermann et al. (2022) identify several digital nudges such as priming, goal setting, defaults, feedback, social reference, and framing which can support behavioural change. Similarly, Shevchuk et al. (2019) find that gamification as a design feature can increase perceived persuasiveness in the promotion of sustainable energy behaviours.

Prior efforts in promoting energy-efficient behaviours typically focused on individual characteristics and average consumption data (Geller et al., 2006; Heiskanen et al., 2010) rather than a deeper understanding of daily routines in energy use (Silvast et al., 2018; Stragier et al., 2013). For instance, studies investigating the impact of socio-demographic factors have found that gender and age explain some aspects of a user's energy practices (Brounen et al., 2013). Similarly, household characteristics related to the age and the size of the dwelling are used to direct promotion efforts (idem.). Such strategies for targeting "static" individual characteristics are typically seen as straightforward and low-risk; it is far easier to develop an intervention for a user segment with stable characteristics than to target diverse segments that perform different energy-consumption routines.

However, this "static" conceptualisation of user segments is often based on oversimplified ideas of what drives users to act. Cotton and Devine-Wright's (2012) study of how energy authorities conceptualize users and their engagement practices found that they do not make clear distinctions between groups, but rather, include them in broader categories. The engagement strategies used by energy authorities also assume that users' motivations remain static over time, due in part to the challenges faced when incorporating these considerations into long-term developments. This contrasts with findings from Heiskanen et al. (2015) which found that users self-selected themselves in a variety of different categories. Given the diversity of user groups typically targeted by digital platforms, important consideration must be given to the different characteristics of user segments and the design features required (McCarthy et al., 2022). Further research is therefore needed to understand how sustainable energy interventions can effectively reach different private household users and sustain their interest across longer periods (Vassileva & Campillo, 2014).

2.2 A Socio-Cognitive Perspective of Sustainable Energy Behaviours

To enable a deeper understanding of users' enactment of sustainable energy behaviours, we draw on core concepts from Bandura's (1986, 1991, 2001) Social Cognitive Theory. According to Bandura (2001), human behaviour is the function of a triadic interaction between cognition, behaviour, and environmental factors. We focus attention on three concepts theorised by Bandura (2001) as antecedents of human behaviour for our study: s*elf-efficacy, outcome expectancy*, and *social modelling*. Social Cognitive Theory later expanded to include concepts related to moral disengagement (Bandura, 2002), and personality (Bandura, 1999), which although noteworthy, are not central to our current study.

S*elf-efficacy* refers to a user's belief in their ability to achieve set goals through behavioural change (Bandura, 2001; Venkatesh et al., 2003). Self-efficacy is integral to human agency and exemplifies a relationship between personal belief systems for adaptation or change (McCarthy et al., 2023). Influential sources of self-efficacy include experiencing success after overcoming obstacles which can change perceptions and interpretations of events (Bandura, 1991). Confidence in one's ability in turn shapes how users engage in goal setting and decisions around the expenditure of effort (Loock et al., 2013). Corbett (2013) asserts that information systems can promote ecologically responsible behaviours by reducing the effort it takes to calculate the impact of behaviours, and tailoring content so that it is more relevant to the specific use context.

Outcome expectancy centres on a user's beliefs about the consequences of their behaviours (Bandura, 1986; Venkatesh et al., 2003). Users' cognitive processing of future outcomes serves an important purpose by providing information on how to structure actions to obtain the desired results in the wider environment (Venkatesh et al., 2003). Through this process, one can address conflicts in motivation, which Bandura (1991) suggests is the primary factor of behavioural change. Previous studies point towards several different outcome expectancies when using digital technologies, such as pro-environmental behaviour (Leidner et al., 2022; Sim et al., 2023), and managing energy prices (Wörner et al., 2022). Positive experiences can in turn affect a user's attitude towards digital sustainability platforms over time, reinforcing consumption and encouraging individuals to engage further in a behaviour (cf. Bandura, 2001).

Lastly, *social modelling* centres on a user's vicarious identification with social groups in the wider environment which serve as role models for new behaviours (Bandura, 1986). Human agency involves consciously thinking about the 'rightness or wrongness' of action which is evaluated against situational/environmental conditions (Bandura, 1991; McCarthy et al., 2023). Social modelling provides an opportunity for individuals to reevaluate the motivation, values, and meaning of their pursuits relative to social norms. Persuasive systems can also serve as a social benchmark for users to evaluate pro-environmental behaviours, offering feedback that supports commitment and learning over time (Corbett, 2013; Wörner et al., 2022). Information from the environment that is inferentially processed can be weighed and combined to guide behaviours over time (Bandura, 1986). For instance, users can gain experiences through vicariously observing 'role models' similar to themselves which provides insights into the behavioural obstacles they need to overcome (Seidel et al., 2013).

Table 1 provides an overview of the core concepts from Bandura's (1986, 1991, 2001) Social Cognitive Theory with examples of relevance to digital sustainability.

A primary challenge facing practitioners is that information provision often fails to impact user behaviours, even where economic incentives are evenly distributed (Geller et al., 2006; Heiskanen et al., 2010; Loock et al., 2013). In addition, energy awareness does not always lead to a reduction in household energy consumption (Brounen et al., 2013; Thøgersen, 2018; Van Der Werff et al., 2018; Yohanis, 2012). While inaction is rarely perceived as a "choice", Dursun et al. (2019) have found that denial mechanisms have direct effects on sustainable energy behaviours. They suggest that denial of responsibility and denial of effectiveness hinder positive action as users may even deny the existence of a problem altogether (Dursun et al., 2019). Heiskanen et al. (2010) suggest that user inaction and denial primarily result from interventions that fail to account for the socially grounded nature of behaviours.

A static model is therefore unlikely to be effective for digital platforms that target diverse user groups as behavioural needs differ and can evolve (McCarthy et al., 2022). To address these aforementioned challenges, practitioners must therefore seek to better understand target groups and match digital interventions with their temporal needs (cf. Wilhite et al., 2000). Bandura's (1986, 1991, 2001) Social Cognitive Theory provides a well-rounded approach to consider users' enactment of sustainable energy behaviours.

We turn next to review how changes in energy behaviours over time can be understood through the concept of user touchpoints (cf. Lemon & Verhoef, 2016) and posit that touchpoints can help with understanding different user representations for digital sustainability design.

2.3 User Representations and Touchpoint Mapping

Recent studies on sustainable energy behaviours have sought to develop more nuanced portrayals of user segments by envisaging their different characteristics and requirements for a new system (cf. Johnson, 1988; Madeleine & Latour, 1992; Silvast et al., 2018). These user representations help in revealing users' relationships with technologies and how existing relationships might be changed (Shittu, 2019; Skjølsvold & Lindkvist, 2015). Prior literature demonstrates the value of user representations when designing digital interventions. For instance, Skjølsvold and Lindkvist's (2015) study on 'user imaginaries' in the European smart grid shows IT development processes are strongly influenced by developers' perceptions of users and their expectations. They also find that actors developed different representations to envisage users' role in sustainable energy systems. This helps in identifying important determinants of energy consumption patterns as well as individuals' understanding of environmental impact (Brounen et al., 2013; Thøgersen, 2018; Van Der Werff et al., 2018; Yohanis, 2012).

User representations can also capture the variety of channels that shape users' perceptions of technology over time (Gölz & Hahnel, 2016; Wunderlich et al., 2019). According to Lemon and Verhoef (2016), these 'touchpoints' provide a conduit that shapes users' physical and emotional experience of a product or service (Brynjolfsson et al., 2013; Hamilton et al., 2021; McCarthy et al., 2016, 2020; Zomerdijk & Voss, 2010). Touchpoints can be categorised according to one of three sequential stages (i) *pre-action:* before the user becomes aware of the product or service through different channels or media, (ii) *during action:* the process when users access or purchase the product or service, and (iii) *post-action*: after the user integrates the product or service into their daily practices (cf. Jürisoo et al., 2018; Lemon & Verhoef, 2016; Stickdorn & Schneider, 2011). Some touchpoints may be within the user's reach, while others remain outside their control such as those owned by energy providers and regulators (Lemon & Verhoef, 2016; Norton & Pine, 2013).

Journey mapping aims to place the user at the heart of the modelling process by mapping a series of touchpoints that shape their experiences of a product or service (Johnston & Kong, 2011). While an organisation can manage product and service offerings, the experience that each user derives from

Table 1 Core concepts from Social Cognitive Theory and their relevancy to Digital Sustainability

Concept	Description	Example
Self-efficacy	A user's evaluation of their agency to change events and situations (Venkatesh et al., 2003). This can involve adjustments, revisions, and refinements of existing and new behaviours (Bandura, 2001).	Digital sustainability can help users reappraise their agency to control energy behaviours through tailored content.
Outcome expectancy	A user's beliefs about the potential outcomes of their behaviours (Bandura, 1986). This links thought to action through self-monitoring behaviours and information feedback.	Digital sustainability can help users understand the different impacts of sustainable energy behaviours over time.
Social modelling	A user's reflective evaluation of the motivations, values, and meaning of their pursuits relative to others (Bandura, 1986). This involves judging actions and outcomes based on others' beliefs/values (Seidel et al., 2013).	Digital sustainability can provide social cues that shape users' evaluation of stainable energy behaviours relative to others' motivations and values.

these offerings is unique. Envisioning different user representations and their touchpoints with products and services can yield particularly valuable insights into the requirements for systems and platform design. For instance, Sinitskaya et al. (2020) use journey maps to explore the tensions and pain points associated with purchasing and installing solar panels and suggest that different challenges may be experienced during different stages.

Inspired by an interest in user representations, we apply the concept of user journeys to analyse how energy efficiency can be promoted through digital platforms over time, leveraging insights from both energy experts and users. We next present the research design behind our study.

3 Method and Data

A multimethod research study (cf. Mingers, 2001) was conducted as part of a 36-month energy sustainability project called ECO2. The project was funded by the EU Commission's Horizon 2020 programme and involved a consortium of private and public organisations across nine countries including Denmark, Finland, Ireland, Italy, Belgium, Lithuania, Bulgaria, Portugal, and Greece.

ECO2 aimed to develop a digital platform that would increase users' awareness of their energy consumption habits and enable them to improve their household energy efficiency through behavioural change initiatives. This involved enhancing users' knowledge of how to consume energy more consciously in their everyday lives and empowering them to implement concrete actions for saving energy. The resulting digital sustainability platform ACT4ECO was designed to support transformative behavioural change, guiding users on the adoption of energy-efficient practices that would reduce their CO2 footprint. Users would climb a "ladder of change" from 'Motivation' to 'Exploration' and finally to 'Action' where they make more environmentally sustainable energy choices. During these three sequential stages, users would become increasingly conscious of the role of energy-efficient practices in the transition to a low-carbon future. This goes beyond information provision to recognise users' prior knowledge and available resources for change. ACT4ECO aimed to help users acquire knowledge through step-by-step interactions that would prepare them for action and behavioural change in their daily practices over time.

To support users in adopting energy-efficient behaviours on a magnitude that makes a difference in energy systems transformation, the platform was made available for free and in multiple languages. The project aimed to reach over 11,000 citizens across Europe who would sign up for the platform. The intermediate outcome of awareness raising was measured as users progressed through the platform's topics which included: "Become a smart user", "Manage your energy consumption", "Prevent energy rebound", "Improve your house", and "Produce your own energy". Final behavioural outcomes, meanwhile, were measured as each user recorded 2–3 completed actions to increase their household energy efficiency. This included actions such as improving the air tightness of a house, choosing a new boiler, and moving to renewable energy sources. Based on these actions, it was estimated that an average 5% increase in energy efficiency was achieved per engaged user, resulting in an overall saving of approximately 4.2 GWh.

The authors were directly involved in the project and represented Finland and Ireland in the ECO2 consortium. Their involvement primarily centred on recruiting target user groups in both countries and soliciting feedback on the ACT4ECO platform's evolving design. This feedback was subsequently shared with the ECO2 development team and incorporated into the platform. The current research covers the 36-month timeframe of the project with the lead author remaining as an active member of the consortium throughout.

3.1 Data Collection

Following a purposeful sampling strategy (cf. Patton, 1990), we gathered qualitative data from two nations involved in the ECO2 project: Finland and Ireland. The comparison between the two countries was motivated by three aspects: 1) The two energy markets represent different levels of maturity. Finland completed its first phase in the roll-out of smart meters in 2013, whereas in Ireland the smart metering deployment occurred more recently in 2019 (European Commission DG Energy, 2019). These differences may also be reflected in the user representations of energy providers and their outreach measures. 2) The countries were also chosen based on their similar population size and decentralized energy markets, where sizable challenges have been faced in realizing the goal of sustainable energy transitions. In both countries, energy efficiency is being actively promoted by various actors, including public agencies, private energy companies and providers, and NGOs, who at times develop joint interventions. 3) Climate conditions, building stock features, and culture of building maintenance are other important comparators between the two countries that shape the energy consumption context and user needs.

Data was collected from three sources: 11 semi-structured interviews, a follow-up co-creation workshop with 14 energy experts, and a survey of 62 ACT4ECO users. Following the guidelines of Mingers (2001) and Venkatesh et al. (2013), a 'sequential' design was adopted using qualitative methods (interviews and co-creation workshops) for exploration, and quantitative methods (a survey) for confirmation. Sub-questions were defined for each round of data collection.

Firstly, the authors conducted 11 semi-structured interviews with energy experts (EE) from Finland (6 interviews) and Ireland (5 interviews) during the Spring–Summer of 2018 (identified as EE 1–11). This round of data collection sought to investigate the sub-research question: *How can digital sustainability platforms support energy-efficient behaviours across different user groups?* The interview sample included actors from leading-edge public and private organisations and NGOs promoting energy efficiency, including academic and industry experts in the energy field (see Table 2). The respondents had experience in organising numerous interventions and research activities. They were also chosen for their substantive knowledge of energy efficiency promotion, dissemination and hands-on user engagement which made their expertise very relevant to our study. The interviews with energy experts covered several topics, such as the different user groups targeted by digital sustainability initiatives, and how to encourage energy-efficient behaviours in practice (see Appendix A). Recorded interviews took on average one hour to complete and were transcribed verbatim by the authors.

This was followed by a two-hour co-creation workshop with 14 energy experts in Ireland during the Summer of 2020 focusing on the topic "Becoming a smart user" (identified as EE 11–25). A new group of experts were recruited to ensure diverse representation and add new insights to those provided by the experts in Study 1. The co-creation workshop did not take place in Finland due to changes in the ECO2 consortium around this time. The second round of data collection aimed to provide insights into the following sub-research question: *Why do digital sustainability platform users face challenges in adopting energy-efficient behaviours?*

Participants from a variety of backgrounds (see Table 3) were invited to provide feedback on functionality implemented in the platform to support energy users' transitions towards sustainable household energy practices. Participants were also invited to reflect on the current environmental situation as well as the potential future recommendations on how to improve it through digital solutions. Their feedback further informed new design features that were developed subsequently. The co-creation workshop lasted for 2 hours, and was conducted in English using a semi-structured approach. Representatives of the project team moderated discussions. The introduction of COVID-19 restrictions meant that participants had to engage remotely through Zoom video conferencing.

Lastly, we collected survey data from ACT4ECO users (N = 62) to evaluate the impact of the ACT4ECO platform. This round of data collection centred on the sub-research question: *How effective is ACT4ECO in supporting targeted energy-efficient behaviours among different user groups?* The ECO2 development team provided the authors with access to the list of registered users on the platform. The survey was then distributed to all registered users on May 6th, 2021 with a response rate of 74%. A summary of the accompanying survey is included in Appendix B. Responses were received across all countries represented in the ECO2 project consortium. Figure 1 provides the distribution of respondents' age. The gender distribution was 33.87% male and 66.13% female.

Platform data was also gathered from Google Analytics to provide additional insights on ACT4ECO users. This included metrics such as average session duration, number of sessions per user, page views, bounce rate, and new vs. returning users.

3.2 Data Analysis

We adopted a thematic analysis approach (cf. Braun & Clarke, 2006) consisting of four phases to code our qualitative data. In phase one, open coding was undertaken by the first, second, and fourth authors to analyse patterns in the data related to user segments, their level of energy awareness, and the practices they engage in within the private household. This included codes such as routine energy practices, motivational factors, and the role of different smart technologies in behavioural change (see Appendix C). Case analysis meetings were also organised with all members of the author team to verify and validate the findings. This involved exposing any initial codes to scrutiny and challenging any underlying assumptions around the outputs from data analysis.

In phase two, we sought to develop analytical categories for user representations and started by coding groups based on the absence and presence of users' energy awareness. During the coding, a more refined understanding of energy awareness crystallised into three dynamic user representations: *energy unaware*, *living in denial*, and *energy-aware and active*. The data suggest that in contrast to *energy-unaware users* who remain uninformed, *living in denial users* are cognisant of energy matters yet neglect to act on such knowledge. *Energy-aware and active* users meanwhile are cognisant of energy matters and proactively undertake different actions to influence their energy consumption.

In phase three, we categorised the factors that motivate behaviour across each user representation group building on concepts from Social Cognitive Theory, namely: *self-efficacy*, *outcome expectancy*, and *social modelling* (see Table 1). This further informed the generation of design principles that would inform the development of the digital platform in the study. Based on our analysis, we identified seven design principles related to each concept. Our data suggest that static user representations, anchored in socio-demographic features such as age, gender, and place of

Table 2 Interview respondents: roles, expertise, and affiliation

Role and ID	Expertise	Affiliation
Energy Solutions Manager (EE1)	Specialist in housing renovation and renewable energy solutions for sustainable buildings.	Finnish private electricity company that leverages market mechanisms and smart products for household energy efficiency.
Climate and Energy Expert (EE2)	Leading expert in energy efficiency promotion and the execution of campaigns for behavioural change in private households.	Finnish public NGO focused on advocacy and community engagement to promote sustainable energy practices at the grassroots level.
Researcher (EE3)	Expert in energy markets, the development of energy services, and the implementation of pilots.	Finnish university that supports innovation in energy-efficient technologies through academic research and teaching.
Sustainability Campaigner (EE4)	Advocate for carbon neutrality, with a particular emphasis on sustainable actions and choices.	Public innovation centre in Finland that serves as a hub for collaborative research on technologies for energy efficiency.
Policy Expert (EE5)	Specialist in carbon neutrality through energy-efficient housing, and sustainable approaches to transport.	Same affiliation as EE4.
Energy Efficiency Manager (EE6)	Practitioner focused on the energy economy and leader of national campaigns targeting the public sector, businesses, municipalities, and users.	Public development agency in Finland that implements policies and programs that align with broader socio-economic goals for energy-efficient practices
Researcher (EE7)	Specialist in energy efficiency modelling on national and EU levels, and outreach campaigns for users.	Public energy institute in Ireland that drives cutting-edge research in effective strategies for household energy efficiency.
Program Manager (EE8)	Practitioner focused on initiatives that promote behavioural change strategies for household energy efficiency.	National authority for sustainable energy promotion in Ireland that develops energy efficiency campaigns.
Senior Executive (EE9)	Strategist involved in translating companies' needs into energy research offerings in communication with different stakeholders.	Public centre for energy research in Ireland that conducts exploratory studies to inform policy and technological advancements in household energy efficiency.
Project Manager (EE10)	Specialist in environmental sociology and coordinator of a European project on living labs for energy efficiency.	Irish university that conducts academic research on the development and testing of energy-efficient practices in households.
Chief Executive Officer (EE11)	Consultant in energy efficiency and climate change, providing recommendations to national and European governments.	Private energy agency in Ireland that serves regional needs, implementing tailored initiatives to enhance energy efficiency within communities.

Table 3 Summary of co-creation workshop participants

Group	Expertise	Affiliation
Policymaking (1 representative)	Authority that promotes and aids in the development of sustainable infrastructure and housing renovation through grant schemes and community initiatives.	National energy authority established to support Ireland's transition to a low-carbon energy future. Advises the government, businesses, and communities on strategic measures to achieve energy objectives.
Academia (6 representatives)	Researchers and professors focused on sustainable transitions and socio-material influences on consumption and production patterns.	Research cluster in Ireland's university sector comprising of interdisciplinary experts who seek to advance knowledge and develop solutions for energy efficiency.
NGOs (2 representatives)	Energy-efficiency advocates concerned with how knowledge is communicated between policymakers, civil society and industry.	Non-governmental organisations responsible for delivering public services, managing resources, and implementing policies across the county and city areas.
Business Organisations (3 representatives)	Dominant players in the electricity market operating in the areas of electricity generation, transmission, and distribution to supply.	Supply board and other energy providers that play a crucial role in the generation, transmission, and distribution of electricity infrastructure across Ireland.
Local Authorities (1 representative)	Council members responsible for sustainable housing, infrastructure, urban planning and development, and pro-environmental initiatives.	Local government authority (district council) dedicated to advancing sustainable practices and optimising energy usage within their geographical area.
Initiative Coordination (1 representative)	Project manager responsible for developing and implementing several sustainable community-led projects.	Promotion agency committed to engaging and mobilising local communities toward energy-efficient practices.

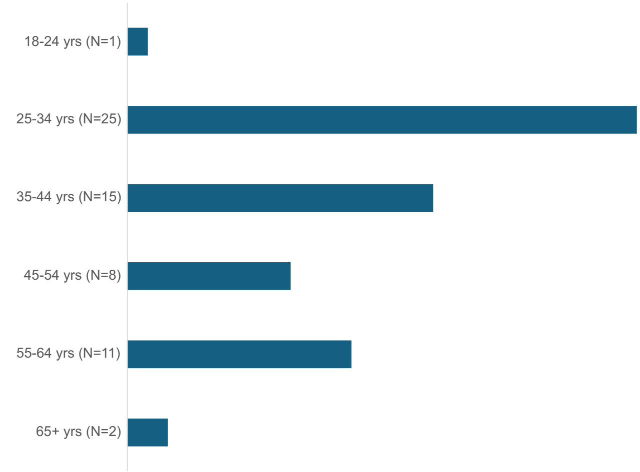


Fig. 1 Age distribution of survey respondents

residence, are increasingly giving way to dynamic user representations that are grounded in attitude-based evaluations. This revealed the importance of understanding socio-cognitive dispositions as an integral part of users' behaviours and how they change over time.

Consequently, in phase four, we sought to conceptualise these changes as 'user journeys' by coding touchpoints which a digital sustainability platform should educate different user representations about (Baxendale et al., 2015). According to Lemon and Verhoef's (2016) typology, there are four types of touchpoints: *user-owned*, *social/external*, *brand-owned*, and *partner-owned*. User-owned touchpoints are actions that are directly controlled by users and form part of their overall experience. This can also include household appliances and devices which may influence user journeys beyond a single encounter and shape future expectations or choices. Social/external touchpoints centre on the wider environment and the influence of peer feedback on users' experiences of a product/service. Brand-owned touchpoints are those that are designed, managed, and controlled by a focal agent such as energy service providers, landlords, and the media (e.g., advertising and websites) (cf. Baxendale et al., 2015; Lemon & Verhoef, 2016). Lastly, partner-owned touchpoints are those that are jointly designed, managed, and controlled by partners in the energy sector such as market regulators, infrastructure providers, and public agencies tasked with shaping users' behaviours and practices. The relative importance of each touchpoint in the user journey was also analysed.

Figure 2 provides an overview of each data collection and analysis step in our multimethod study.

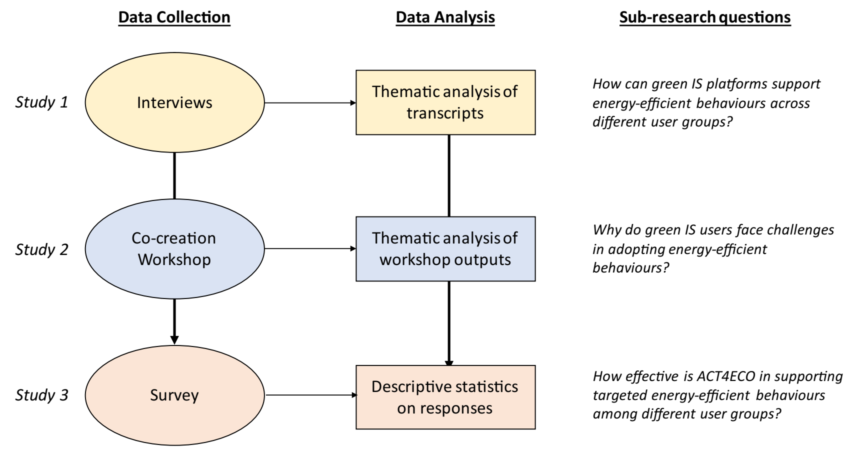


Fig. 2 Summary of Data Collection and Data Analysis

4 Results

4.1 User Representations and Self-Efficacy

A defining characteristic of the energy-unaware user was 'obliviousness' to the environmental impact of user-owned touchpoints and their limited self-efficacy for change. While the majority of respondents agreed that "*Avoiding the in vain consumption of energy is a priority [for energy efficiency]*" (EE9), many users are unable to calculate how their daily energy consumption behaviours contribute to CO2 emissions. Respondents noted that for most users "*Energy is something "invisible" and people pay limited attention to hidden features of their consumption data/energy bills details*" (EE15). Support was therefore required to enable this user group to make concrete changes in their everyday energy use activities (i.e., heating and transport). This centres on the routine tasks that users may traditionally have engaged in unconsciously. As stated by one respondent: "*Day-to-day practices is one of the only areas in which I actually believe that [digital sustainability platforms can] work well*" (EE19). Awareness raising was identified as an important objective so users can grasp the low-effort energy-saving actions, for instance, by unplugging standby devices, switching off lights when not needed, or reducing heating consumption. However, respondents noted that it is still notoriously difficult to alter routines as "*behaviours are often deeply ingrained in social norms, cultural norms [and] it's hard to get the message across to people on why they should change their behaviour*" (EE2). As an example, it is common for many people to shower every morning, throw clothes in the laundry without checking whether they are dirty, and "*don't even stop to think 'what are we doing here?'*" (EE6).

> **Design principle 1:** The digital sustainability platform should enable users to anticipate the impact that changing routine actions can have on energy consumption and CO2 emissions.

Users' ability to understand their energy bills was also highlighted as a key issue for self-efficacy. One respondent noted that one of the biggest barriers to change for users living in denial is the brand-owned touchpoints of energy providers which often provide information that is hard to understand: "*It is hard for some [users] to get good, reliable and actionable feedback on their energy use without going to decent lengths themselves*" (EE8). Many users are also being encouraged to adopt automated billing by energy providers, which can reduce the salience of energy costs in their minds: "*People don't check email or web tools for energy feedback*" (EE8). This was confirmed by another respondent who noted that many energy providers are offering incentives for people to select direct debit payment which means users often do not notice changes in their energy bill unless they are significant. Users also tend to buy from energy providers that they have bought from before rather than proactively surveying the market for more pro-environmental options. Access to meaningful information is therefore key to helping living in denial users to care about their energy practices: "*Energy consumption should be communicated in a more meaningful way to users; [they] need to be aware of the "why" such as lowering energy bills and the "how" of becoming an active energy user*" (EE21). This goes beyond the reporting of total energy consumption (delivered through partner-owned touchpoints) in metrics such as "*kWh as it may only help some users to decide and analyse where they should act*" (EE19).

> **Design principle 2**: The digital sustainability platform should provide clear information on users' bills and energy consumption practices to guide behavioural change.

Finally, market-level touchpoints over which users have little influence are equally important for improving energy consumption practices. Some pointed out that while users know little about national and EU energy regulations, it is a key factor in their transition towards sustainable energy behaviours. For instance, the policy-driven initiative of rating a building stock's energy efficiency was highlighted as a strong influencer in energy-aware and active users' adoption of sustainable energy practices. National carbon tax, an Irish policy rather than a transposition of an EU directive, was also identified as an example that had a "*strong influence on user behaviour*" (EE5). However, while regulator directives were deemed to be a driver of energy efficiency for some users, many countries have been slow to implement them which limits their effectiveness for behavioural change: "*The EU is pushing us, but we are dragging our feet a little bit*" (EE5).

> **Design principle 3**: The digital sustainability platform should support users in evaluating how regulations influence their decision to invest in energy-efficient practices.

4.2 User Representations and Outcome Expectancy

Respondents agreed that users living in denial do not feel a sense of urgency to take actionable steps for change. While the smart meter rollout (brand-owned touchpoint) has reached almost full penetration in Finland, it was noted that many have not taken advantage of the opportunity to track energy consumption (user-owned touchpoint): "*We have this [energy monitoring tool] but surprisingly few use it"* (EE1). Further respondents noted that most users are "*not very energy conscious [and] people are more interested in convenience, comfort […] rather than energy*" (EE6). Other user-owned touchpoints connected to daily practices mentioned by respondents include excessive consumption of water, travelling and mobility e.g., commuting by car even when public transport is available. They suggest that users' understanding of the outcomes that can be expected from changing routine practices is low. Respondents also asserted that while some users living in denial are probably energy aware, they are still not willing to forgo their standards of living due to uncertainty around other gains at a personal and societal level: "*[users] know that showering in the morning and a long hot shower in the evening consumes a lot of energy but then again they like it and indulge themselves*" (EE3).

> **Design principle 4**: The digital sustainability platform should highlight the urgency of changing energy consumption behaviours for climate action.

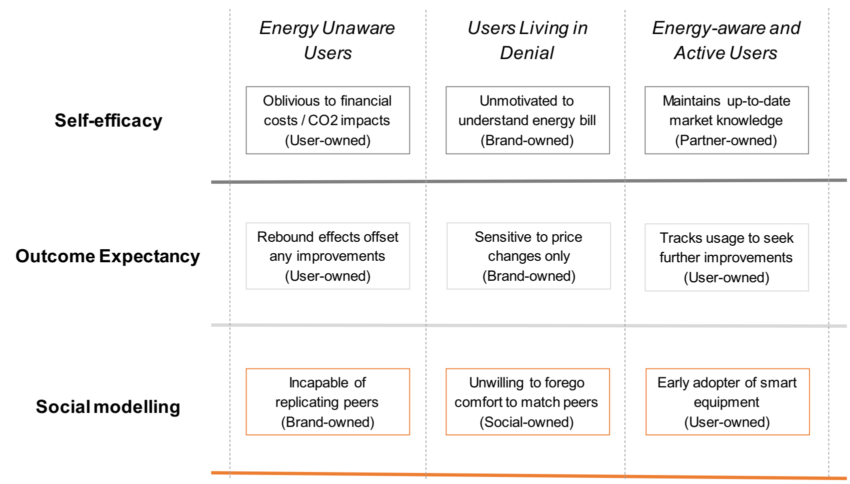
Respondents also discussed the issue of 'energy rebound', where energy efficiencies gained by renovations and energy-saving initiatives are offset when energy unaware users unconsciously engage in new or modified behaviours that consume other energy resources. The 'rebound effect' was mentioned in connection with heating where efficiency gains are lost when people buy bigger dwellings, or where users consume less fuel but buy a second car. One respondent noted that there is also a significant rebound effect when people lower the heating temperature but leave it on more often (user-owned touchpoints): "*It's one thing having a more efficient boiler but if you have it on for twice as long, you're not going to save any energy*" (EE6). This contrasts with energy aware users who adopt a whole suite of digital interventions and action plans to inform their outcome expectancy. Some respondents stated that interventions focused on the price of energy meanwhile were the most influential for users living in denial. As one Finnish respondent noted: "*Saving the world and money motivates [users], especially when combined*" (EE10). However, while it was recognised that people often need economic incentives to change their behaviour, this may not motivate everybody. One respondent noted that people with "*middle to low income would be more likely to [seek] out energy cost savings and people who are in a higher income bracket are more motivated by comfort*" (EE8). According to another respondent, education is therefore needed on financial outlay and payback as "*the vast majority of users haven't deployed any technology in terms of energy efficiency in their home*" (EE4).

> **Design principle 5**: The digital sustainability platform should educate users on how to avoid the issue of energy rebound and its impacts on financial expenses.

4.3 User Representations and Social Modelling

Respondents identified the energy-aware and active users as those who implement a variety of energy renovations including heat pumps, home insulation, and smart equipment such as LED bulbs. These users strive to become early adopters of energy-saving technologies and encourage others to follow suit through social/external touchpoints. Respondents noted the importance of a user's motivation to make changes: "*It takes a lot of effort and a DIY-like mindset [to figure out smart equipment] for an ordinary person or somebody who is not that interested*" (EE11). The respondents argued that purchasers of both self-built and existing new homes are typically more knowledgeable on how to achieve energy efficiency. This includes easy actions such as switching to LED lamps, actions of medium difficulty such as the adoption of smart meters for tracking energy use, and more difficult actions such as home renovation. However, another

Fig. 3 Summary of findings



respondent noted that "*Smart energy consumption goes beyond using smart devices. It also encompasses a responsible attitude to how we consume energy and how we could consume less"* (EE20). While energy aware and active users are often motivated by environmental values, users living in denial are more sensitive to changes in comfort. In Ireland, the respondents argued that energy use was driven mostly by individual heating needs as necessitated by seasonal changes. Given that most of the building stock is old, energy retrofitting of the existing buildings is needed. Investments in retrofitting are often driven by seasonal effects as "*when it gets really cold people start to really care about why their house is cold*" (EE8).

Design principle 6: The digital sustainability platform should present users with role models on how they can improve their resilience against seasonal impacts using smart devices to improve their energy consumption.

Respondents highlighted the influence of positive examples set by neighbours, friends, or family. One respondent reflected on the topic by saying "*Neighbour envy [is crucial]. If the neighbour has a solar panel and they bike to work or have an energy-saving car in the driveway, [it's] an incentive*" (EE10). However, household ownership was identified as a barrier to many energy unaware users. This was due to the property structures and split incentives between tenants and landlords. Collective decision-making in apartment buildings appears to reduce opportunities to act. While tenants may realise that energy renovations are economically sound, they do not have the property rights possessed by landlords to make necessary changes. Heating is also a touchpoint that is often out of users' reach in apartment buildings as residents are instead presented with a monthly maintenance fee that includes both heating and water. Non-energy services like cleaning and renovation may also be lumped in the maintenance fee, which reduces users' awareness about energy-consumption payments. For instance, in Finnish households, apartment heating consumes the highest share of energy but due to maintenance fees, this is often not visible to the user. This lies in contrast to detached houses where inhabitants pay their bills separately.

Design principle 7: The digital sustainability platform should ensure behavioural change recommendations and social comparators are tailored to the users' current housing status.

Figure 3 summarises key results from our multimethod study on the touchpoints that influence energy-efficient behaviours among different user representations. The journey of each user representation (energy-unaware users, energy users living in denial, and energy-aware and active) is depicted across user-owned, brand-owned, partner-owned, and social-owned touchpoints, with the key social cognitive processes outlined on the right (as discussed in sections 4.1 to 4.3).

5 Evaluation

Our findings on user representations and touchpoints later informed recruitment for and the design features of ACT4ECO. The ACT4ECO platform aimed to serve all three user representations by guiding users through a 'ladder of change' from "Motivation" (*energy-unaware users*) to "Exploration" (*users living in denial*) and finally to "Action" (*energy-aware and active*). The energy experts' input and resulting design principles (DP) were embedded across five topics which the user would navigate through using a dedicated path: i) "Become a smart user" (DP1, DP4), ii) "Manage your energy consumption" (DP2), iii) "Prevent energy rebound" (DP5), iv) "Improve your house" (DP3, DP6), and iv) "Produce your own energy" (DP6, DP7). The five topics are displayed at the top of ACT4ECO's user interface (see Fig. 4) which users can

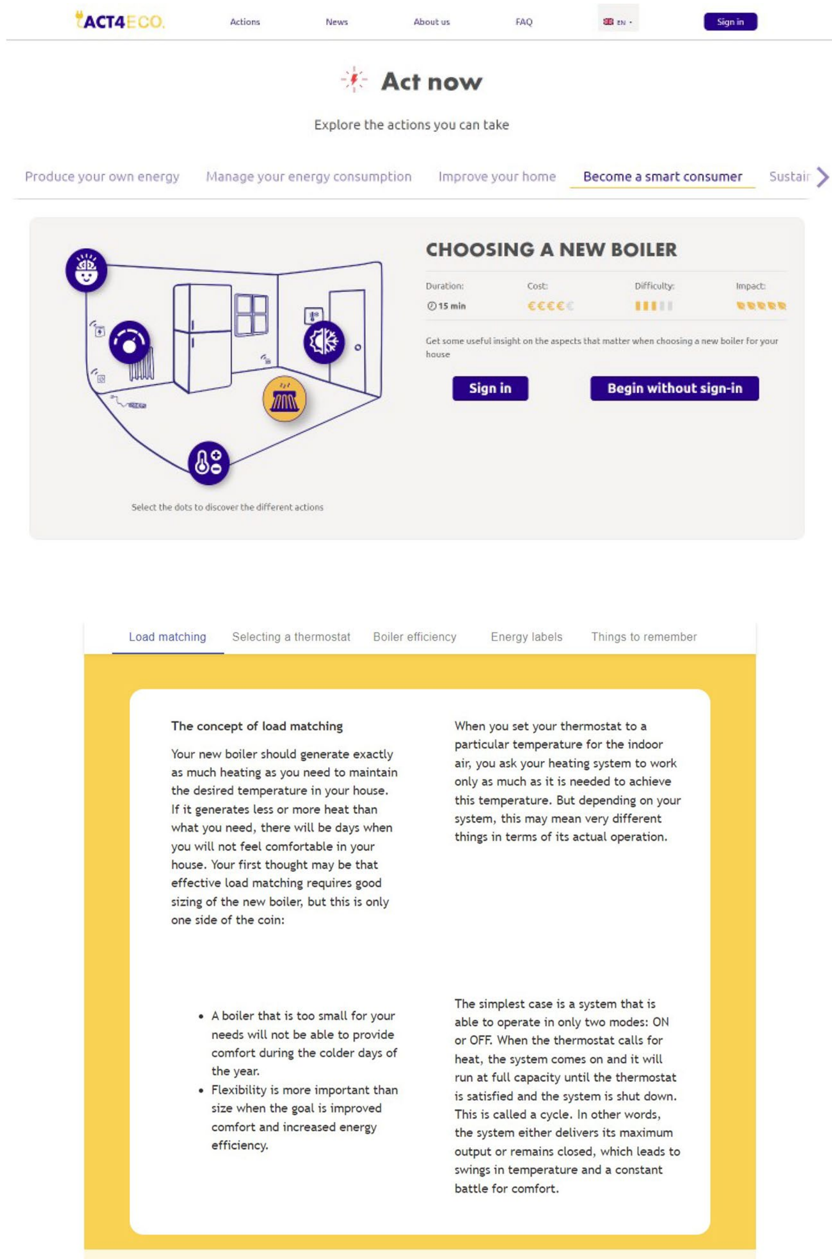


Fig. 4 Screenshots of ACT4ECO's 'Ladder of Change'

cycle through to see more information. Once they click on a topic, they then see the sub-actions that can be completed as displayed in the centre of Fig. 4 e.g., "Load matching", "Selecting a thermostat", "Boiler efficiency", "Energy labels", and "Things to remember".

To support this process, the user would receive a mix of instructional information, assessment for reflection/deliberation, and action plans on the next steps to take across the identified touchpoints. Each section of ACT4ECO was given a difficulty rating to allow users to evaluate their *self-efficacy* to complete, while additional indicators such as cost, impact, and duration were provided to support users' evaluation of *outcome expectancy*. A set of best practices was also provided for actions with higher difficulty ratings to support *social modelling*.

We next provide an overview of survey data on users' evaluation of the platform. Responses were received across all three user representations with 10% stating they had no energy efficiency knowledge before using the platform (corresponding to *energy unaware*), 59% said they had some knowledge about the topic but had not changed their behaviours (corresponding to e*nergy aware and living in denial*), while 31% had good knowledge or were experts on the topic (corresponding to *energy-aware and active*).

Based on their interaction with the platform, 76% of survey respondents indicated they intended to "*implement*

Table 4 User evaluation of ACT4ECO

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
The contents corresponded to my expectations	13%	63%	15%	9%	0%
The contents responded to my needs	11%	63%	22%	4%	0%
The contents were adequate for my previous knowledge	22%	54%	17%	7%	0%
The contents are a useful resource for me to go back to	26%	52%	15%	7%	0%

changes in terms of energy consumption and energy efficiency". This included adapting their energy consumption behaviours (78%), monitoring their energy consumption (29%), and changing to energy-efficient appliances (22%). Their responses included further sub-actions such as turning off lights and unplugging appliances to adapt behaviours and monitoring the energy demand of thermostats and washing machines/ovens/fridges (corresponding to high *self-efficacy*). Users also noted that they have changed to energy-efficient appliances such as smart meters to evaluate their bill (*outcome expectancy*). Interestingly, of these respondents, 100% stated that these changes will continue to be part of their lives going forward and 51% said they are very motivated. "*Community inspiration*" was highlighted as a means to maintain these changes which reaffirms the impact of *social modelling* and social/external touchpoints. However, house ownership, as well as financial and time constraints were highlighted as impediments to behavioural change in the open answer questions.

Digital sustainability content on user-owned touchpoints was deemed to be most interesting to users including educational material on appliance energy consumption (61%), controlling energy consumption (59%), and managing energy bills (59%). In contrast, content related to partner-owned touchpoints (e.g., market regulations and finance schemes for household renovations), and brand-owned touchpoints (e.g., energy pricing) were evaluated as less understandable to users.

Table 4 provides a summary of users' perceptions of the content which suggests that the majority agreed that the ACT4ECO platform provided useful content that responded to their needs for behavioural change.

Platform data collected later on the 8148 registered users, however, points to the challenge of sustaining user engagement over time. The average session duration on ACT4ECO was 5 minutes and 57 seconds for regular users (those who engaged in three or more sessions) compared to 1 minute and 7 seconds for occasional users (those who engaged in less than three sessions). Regular users also made up a minority (17%) of the total user base and had a recorded bounce rate of 49%. Survey respondents also suggested improvements to increase engagement going forward such as targeted action plans (48%), further information on what other users learned or changed (41%), and competition with other users (13%).

We next present a discussion of the theoretical and practical implications from our study.

6 Discussion

This section discusses our contributions to IS scholarship and practice based on the following research question: *How do the touchpoints embedded within digital sustainability platforms interact to influence energy-efficient behaviours among different user representations?*

6.1 Theoretical Implications

Our first contribution is to identify three distinct user representations for sustainable energy behaviours promotion through digital sustainability platforms: *energy-unaware users*, *energy users living in denial*, and *energy-aware and active*. While previous green IS studies report user findings at an aggregated level, our study seeks to differentiate between user representations, their underlying characteristics, and the factors that shape their behaviour. Our analysis is informed by Social Cognitive Theory (Bandura, 1986) and the concepts of *self-efficacy*, *outcome expectancy*, and *social modelling* which can help understand the challenges faced across the three user representations.

The primary challenge faced by *energy-unaware users* is that the resources available to them to adopt sustainable behaviours are insufficient and their self-efficacy for change is low (cf. Bandura, 2001). This extends the work of Loock et al. (2013) by suggesting that user behaviour is influenced not only by goal setting but also by their ability to achieve set goals. Our study highlights the potential of digital platforms for quantifying 'unconscious' energy usage and emission insights to prevent energy rebound. This could be further supported, for example through APIs between smart metres and digital platforms that offer real-time data on the expected outcome of actions to reduce energy use and financial outlay (Sim et al., 2023). *Energy users living in denial* meanwhile, do not feel a sense of urgency to change energy use behaviours and reduce CO2 emissions. We provide support for Corbett's (2013) proposition that social support is an important feature of persuasive green IS platforms. Our findings suggest that *energy-aware and active users* can help reinforce sustainable energy behaviours through social modelling (cf. Bandura, 1986) and the development of external touchpoints (cf. Jürisoo et al., 2018; Lemon & Verhoef, 2016) to actively change users' preferences and motivations.

We further contribute to IS scholarship by extending the nascent discourse on how digital platforms can promote sustainable energy practices at the individual level of private households (Loock et al., 2013; Wörner et al., 2022). In this regard, our study departs from prior studies that *define* energy awareness (cf. Brounen et al., 2013) to investigate how energy efficiency is *promoted* through digital sustainability platforms. Firstly, our findings suggest that getting users to actively notice how much energy they consume is a major challenge. To address 'obliviousness' among *energy-unaware users,* digital interventions are needed to disseminate information on the use of devices and the positive environmental impact of energy efficiency. Such digital interventions can make users aware of their entrenched energy consumption behaviours and inform them of actions they can take (Bigerna et al., 2021; Spagnolli et al., 2011). Secondly, we find that digital platforms must address the issue of 'denial of impact' and 'no sense of urgency' among *energy users living in denial*. This requires features that support users in building a vision for decreasing their energy consumption in everyday practices (Van Der Werff et al., 2018; Yohanis, 2012). Digital platforms can provide knowledge on the effective use of technology to promote energy-conscious behaviours and practices (Gölz & Hahnel, 2016; Laakso et al., 2021; Strengers & Nicholls, 2017).

To advance users towards an *energy-aware and active* representation, our findings suggest that digital sustainability platforms should consider important connections between environmental values (reducing climate impacts for future generations), well-being (maintaining a comfortable living environment), and finance (saving money) to raise interest, especially among energy users living in denial. This builds on previous studies on energy efficiency which point towards structural, social, and cultural factors when defining user representations (Gölz & Hahnel, 2016; Thøgersen, 2018) and suggests that digital platforms can enable positive changes to household energy consumption habits. We therefore extend digital sustainability literature beyond organisational contexts (Degirmenci & Recker, 2023; Leidner et al., 2022; Loeser et al., 2017), to focus on energy-efficient behaviours in private households.

6.2 Practical Implications

We further contribute towards a deepened understanding of the different touchpoints in users' journeys and their relevance to digital sustainability design. Lemon and Verhoef's (2016) typology provided us with a lens to identify several touchpoints that energy experts indicated are important for digital platform design. Our findings contribute to IS practice by revealing the value of touchpoints (cf. McCarthy et al., 2016, 2020) to understand users' journeys in adopting sustainable energy behaviours. Touchpoints have been applied to the context of digital sustainability for understanding how the broader ecosystem of information shapes energy-efficient behaviours. In addition, our contribution to the importance of digital interventions at each stage of a user's journey may be of interest to other researchers studying behavioural change in social and economic sustainability contexts (Doyle et al., 2019; Kotlarsky et al., 2023).

Based on these findings and our resulting design principles (DP), we next outline recommendations for improving the impact of digital platforms across different user representations and touchpoints (see Table 5). Each stage of a user's journey is highlighted as a decisive moment for promoting and sustaining energy-efficient behaviours. The recommendations are further informed by our analysis of concepts from Social Cognitive Theory (SCT), namely: *self-efficacy*, *outcome expectancy*, and *social modelling*. Our findings suggest that the salience of each design principle may vary across different touchpoints and user groups, as noted in Table 5. This is not to suggest a one-to-one relationship, however, as the design principles may also apply to other touchpoints and user groups. Our recommendations nevertheless highlight important considerations for practitioners as a starting point for designing digital sustainability platforms.

Firstly, *user-owned touchpoints* centre on actions that can be directly controlled by users and are outside the remit of energy companies or the market (cf. Lemon & Verhoef, 2016). This includes smart meters which enable the real-time tracking of energy use in private households (Sim et al., 2023; Wunderlich et al., 2019). While smart devices play an important role in supporting behavioural change, our findings suggest that changing daily energy consumption routines remains a challenge. Respondents noted that many users do not adjust their heating controls when leaving home for the day while others may offset efficiency gains by adopting new inefficient energy consumption habits. For instance, *energy users living in denial* perceive ways in which they could reduce their energy consumption at the pre-action stage but continue to engage in habitual behaviours (Degirmenci & Recker, 2023; van den Broek et al., 2019) in the

Table 5 Recommendations for energy efficiency promotion through digital sustainability platforms

Design Principles	SCT Informed Recommendations for Digital Sustainability Platforms	Salient Touchpoint	Salient User
DP5 The digital sustainability platform should educate users on how to avoid the issue of energy rebound and its impacts on financial expenses. See also DP1.	Digital sustainability platforms should inform a user's *outcome expectancy* by demonstrating "the impact of one" for climate action, and the relationship between environmental protection values, costs and comfort. This can in turn increase users' motivation to adopt energy-efficient behaviours.	User-owned	Energy-unaware user
DP7 The digital sustainability platform should ensure behavioural change recommendations and social comparators are tailored to the users' current housing status.	Digital sustainability platforms should recognise the importance of *social modelling* and how the wider environment shapes users' behaviours. For example, users may see the potential for improving their energy efficiency by following peers who have adopted smart home solutions. This can be customised to each user's situation including house ownership.	Social/ external	Energy-aware and active
DP2 The digital sustainability platform should provide clear information on users' bills and energy consumption practices to guide behavioural change. See also DP4 and DP6.	Digital sustainability platforms should enable users to understand their energy bills which can act as enablers or obstacles of *self-efficacy* for sustainable energy consumption. For instance, paperless billing and direct debit payments can reduce the salience of energy costs in people's minds.	Brand-owned	Energy users living in denial
DP3 The digital sustainability platform should support users in evaluating how regulations influence their decision to invest in energy-efficient practices.	Digital sustainability can inform users on how regulatory frameworks affect their *self-efficacy* to invest in energy-efficient practices. This includes, for example, EU and national legislation on building upgrades.	Partner-owned	Energy-aware and active

post-action stage. Our findings suggest that digital sustainability platforms should therefore aim to highlight the frequency of 'bad' habits in the during-action stage and sustain positive actions in the post-action stage. This is consistent with the "ladder of change" identified in our study where users progress from 'Motivation' to 'Exploration' and finally to 'Action'. We also provide supportive evidence for Wörner et al.'s (2022) suggestion that cost remains a key factor in the adoption of energy-saving behaviours. Our findings present examples of how digital platforms intersect with user choices to influence decisions, informing a user's outcome expectancy on cost and perceptions of comfort as drivers of user behaviour (cf. Laakso et al., 2021).

Social/external touchpoints represent another important consideration for digital sustainability (Corbett, 2013; Lemon & Verhoef, 2016). Our findings suggest that social comparisons can shape user energy behaviours, with peer examples from *energy-aware and active users* mentioned as a way to support behavioural change. For instance, seeing and hearing neighbours discuss their adoption of smart metre solutions can act as a call to action. This also supports recent calls for the creation of energy communities, where collective engagement strategies are used to encourage individual behavioural change (Heiskanen et al., 2010). Problem framing can highlight digital sustainability as a collective response to climate change (cf. Jensen et al., 2019) and combat a sense of despondency around how much impact one individual can have on global environmental impacts. Furthermore, a focus on sufficiency (how much of what is enough) as well as efficiency (i.e., more efficient products or services) in digital platforms can be encouraged through community strategies to assert the impact that collective energy-saving actions can have on addressing global challenges (Sahakian et al., 2021).

When it came to *brand-owned touchpoints*, our findings suggest that while digital services allow users to track consumption in real-time, service structures can also constrain the opportunities for an *energy-unaware user* to change their behaviour. Adapting Lemon and Verhoef's (2016) frame to understand users' awareness of service provisions operated by energy companies, we found that access to energy billing information depends on whether the inhabitant is an apartment owner/landlord or a tenant. For instance, costs may be presented by landlords as lump sums within maintenance fees and rents, which makes efforts to save money on energy fees inaccessible for some. Our findings also discuss instances where users want to implement energy efficiency measures in such contexts but cannot because of the external decision-making rules. Similar challenges can be faced when integrating smart home appliances due to incompatible system interfaces and other connection issues between manufacturers. This can limit opportunities to control the energy use of other households in apartment flats.

Partner-owned touchpoints are also essential considerations for digital sustainability design. This can include touchpoints considered out of reach for *energy-unaware users*, including legislation, directives, and energy governance. We find it important that digital sustainability users receive clear and consistent messages on regulations that might support energy efficiency initiatives. For instance, multi-channel communications with a repeated message can ensure the right actor (individual, household, housing association, or energy community) is targeted and their unique characteristics are recognised. Our study therefore corroborates the importance of awareness-raising efforts for regulatory frameworks and context-aware messaging when communicating with users (Burchell et al., 2015). While the context of our study was limited to the European Union, we believe the findings will also be of relevance to other developed nations with similar energy strategies such as the United States (cf. European Union, 2022).

6.3 Limitations and Future Research Directions

Our findings are nevertheless characterised by limitations which future research can seek to address. Firstly, our study is confined to the antecedents of energy-efficiency behaviours. Future research can seek to investigate users' post-action responses to the outcomes of behavioural change at other stages of the journey and how choices around the use of digital technologies evolve. We also suggest the need for research that explores the variability of our results in other settings and contexts e.g., the workplace and energy communities. A second limitation is that our initial analysis of user representations and user journeys was based on expert responses. While this cannot provide direct insights about users, an expert-based approach is nevertheless valuable in conceptualising the user journey and revealing different factors that influence users over time. We also later gathered user responses through an online survey to better understand these user representations and the digital platform's design supporting their journey towards sustainable energy behaviours. The questions were created to source descriptive feedback from ACT4ECO users and therefore were not subject to the formative and summative validity checks. Nevertheless, design and analytical validity were ensured through the triangulation of data from different sources and ongoing discussions between the author team. This ensured descriptive accuracy, credibility, and theoretical validity by challenging any underlying assumptions during data analysis. A third limitation is that survey data was gathered from all countries in the ECO2 project (not just Ireland and Finland) which may impact the comparability of results from Studies 1 and 2. Nevertheless, Study 3's sample is reflective of the ACT4ECO target user demographic and was chosen as a complement to Studies 1 and 2, proving an in-depth evaluation of the ACT4ECO platform.

Future research can seek to undertake longitudinal studies of users' journeys and the factors that drive temporal changes in behaviour. Questions emerging from our study include how design and development activities are shaped by real-time platform data around users' ongoing interactions with a digital sustainability platform e.g., session time and bounce rate. This can also be extended to data from assemblages of connected devices such as smart meters to enhance behavioural change (cf. Sim et al., 2023). Future research can also investigate the potential of emerging technologies (e.g., Artificial Intelligence, Internet of Things) for changing user behaviours in a digital sustainability context (cf. Kotlarsky et al., 2023; Pan et al., 2022). We also call for research that aims to expand on the user representations identified in our study with insights from the later stages of platform adoption. Future studies can, for instance, investigate the structural factors that shape continuance and discontinuance behaviour on digital sustainability platforms.

7 Conclusion

In this study, we investigated how digital platforms can promote sustainable energy behaviours in private households based on an analysis of diverse user representations and touchpoints. Our findings identified three user representations and the socio-cognitive factors that are perceived as important for promoting energy-efficient behaviours. We further map the touchpoints in users' journeys (cf. Lemon & Verhoef, 2016; Silvast et al., 2018) towards energy efficiency and develop recommendations for improvements going forward. User feedback from the ACT4ECO platform shows support for our design principles and points to the importance of targeted interventions at each stage of a user's journey.

Appendix A

Interview Guideline

1. What is your background and affiliation/organisation?
2. Who are the main energy user segments in [Finland / Ireland]?
3. What are the main differences in energy consumption between these segments?
4. How do the characteristics of each user segment differ?
5. How does energy consciousness in [Finland / Ireland] differ across segments?
6. Who are the 'forerunners' in energy consciousness?
7. Who are the most active users of smart energy services?
8. What user segments are lagging behind in energy issues?
9. What are the main factors that lead to energy-inefficient habits?
10. Why do user segments engage in energy-efficient habits?
11. What are some of the motivational factors that explain the differences in energy consumption and energy consciousness?
12. What are some of the most important interventions for enhancing energy consciousness?
13. Who are the most important actors within the energy market?
14. What are the connections and networks between them?
15. Can you give examples of good practices in energy awareness promotion?
16. What tools or practices have been the most efficient in increasing energy consciousness?
17. What are some of the best ways to save energy in the household?

Appendix B

Survey Questions

Section 1: Personal Information

1. Age

- 18–24, 25–34, 35–44, 45–54, 55–64, 65 + .

2. Gender

- Male, Female, Other.

3. Country and municipality where you live

- Text field.

Section 2: Motivation and Behavioural Change

4. Prior to using ACT4ECO how would you rate your energy efficiency knowledge? (mandatory)

- I had no idea about it.
- I had already some knowledge.
- I had good knowledge about the topic.
- I was an expert about the topic.

5. Did ACT4ECO inspire you to implement any changes in terms of energy consumption and energy efficiency (mandatory) (choose those who apply)

- Yes, I started to monitor my energy consumption.
- Yes, I adapted my energy consumption behaviours.
- Yes, I change to energy efficient appliances /systems.
- Yes, I made some interventions in my house.
- No, I changed nothing.

5.1. (If No in 5) Can you tell us more about why ACT4ECO did not inspire or help you make changes in terms of energy consumption and energy efficiency?

- Text field

5.2. (If yes in 5) Share with us some examples of these changes or new behaviours? (e.g., I started using my thermostat, I replaced old lightbulbs with LED ones, etc.). (optional).

Example 1: _________ Example 2: _________ Example 3: _________.

5.3. (If yes in 5) Do these changes continue to be part of your life?

- Yes, no.

5.4. (If yes in 5) How motivated are you to maintain these changes or new behaviours in the future?

- Very motivated • somewhat motivated • slightly motivated • not at all motivated.

5.5 What will help you maintain these changes or new behaviours in the future? (e.g., availability of public funds, more awareness-raising campaigns/ more accessible information on the media, inspiration from my community, etc.) (if yes in 4)

- Open answer

Section 3: ACT4ECO and Energy Efficiency Green IS Platforms

6. Where do you usually look for information about energy efficiency? (Choose those who apply)

- Press (journals, articles), Information materials of reliable organisations, Training courses (online or face to face)
- Internet search
- Social media
- Other____________

7. What did you expect to find on ACT4ECO? (mandatory)

- Information on how I can save energy.
- Information on how I can reduce my energy bill.
- Information on how I can reduce my CO_2 emissions.
- All of the above.
- Other → please comment.

8. Did you to find the information you were looking for? (mandatory)

- Yes, no

8.1. (If no in 8.) What did you feel was missing and what would you like to see in future digital platforms on energy efficiency? (optional).

- Open answer

9. What actions did you explore? (mandatory)

- Produce your own energy.
- Manage your energy consumption.
- Improve your home.
- Become a smart consumer.
- Sustain efficient energy use.

10. What specific topics did you explore or gained your interest? (Please select the most important 6) (mandatory)

- Appliance's energy consumption, Energy bill, Energy generation, Heating and cooling systems, Home insulation, How to choose new appliances, Impact of behaviours/choices in energy consumption, Rebound effect, Renewable energy, Sustaining energy savings, Control energy consumption, Windows and air tightness, National financing programmes.

11. Regarding the contents of the platform, please classify them according to the following criteria:

(mandatory)

- Contents corresponded to my expectation - scale very much to not at all.
- Contents responded to my needs - scale very much to not at all.
- Contents are a useful resource for me to go back to - scale very much to not at all.
- Other__________.

12. What would encourage you to continue using this or another energy-efficiency platforms more often in the future? (mandatory)

- Open answer.

13. Which of the following would motivate you to learn or change your energy efficiency behaviour? (mandatory)

- Informal groups (experience sharing).
- Formal groups (training context).
- Knowing about others' participation (what they changed or learned).
- Competition/challenge with other persons.
- Having a personal plan to fulfil.
- Other: ___________________.

14. What improvements would you suggest for the platform, both regarding content and technical aspects? (optional)

- Open answer.

Appendix C

Illustrative Coding and Quotes from Thematic Analysis

The table below presents illustrative quotes from the thematic analysis process.

Illustrative Quote	Open Coding	Category
"*Overall European citizens tend to have a relatively low awareness of their energy use […] if you look at surveys from the commission for the regulation of utilities and stuff like that, when people are asked to you know what tariffs rates you're on or different comprehension questions about their energy bill, they tend to not have a very good sense of what's going on.*" (EE8)	Awareness of energy tariff rates	*Energy unaware user*
"*Broadly speaking, people are probably not very energy conscious but there's a big difference between different groups. I think [some] people are more interested in convenience, comfort, stuff like that rather than energy. So it's the services that they get through using energy. I think people are probably aware of their sources of energy but not to the point that they're willing to forego their standards of living.*" (EE10)	Motivational factors for behaviours change	*Users living in denial*
"*Smart solutions provide energy saving actions at the right place and the right time, like nudges […] consumers [are then] aware of the "why"* e.g., *benefits such as lower energy bills, and the "how" of becoming an active energy consumer*". (EE21)	The role of different smart technologies in behavioural change	*Energy aware and active*

Illustrative Quote	Open Coding	Category
"*People lack not only the skills/equipment but many times the time to monitor and analyse their consumptions […] They lack knowledge about the different solutions [and need] tips and advice to households on how consumption can be reduced sustainably through simple measures and changes in behaviour.*" (EE16)	Lack of energy knowledge and skills	*Self-efficacy*
"Most people don't know that, in the long term, they will be achieving economic savings too which is their main drive force […] Consumers should be empowered / enabled to become active energy users." (EE20)	Financial savings from energy efficiency	*Outcome Expectancy*
"*I did a little project in a rural part of Mayo where some people got heat pumps installed. They had been using peat and coal to heat their homes and they were very happy with the [heat pump] system. And when one person in the area got one, they spoke to their neighbours and (then) there were five or seven households that ended up with heat pumps. Because one person decided they'd take the chance and get one, everyone else then came around to see how it worked and saw the benefits. It spread like that.*" (EE10)	Positive example set by neighbours	*Social Modelling*
"One of the things that I used to be quite preoccupied with was the issue of rebound. That idea that saving energy actually results in more energy being used. It's an interesting area cause at the one level you need to focus on the individual but you also need to look at economy wide effects. And you may save energy by replacing the light bulb with a more energy efficient lightbulb but are you going to leave that light bulb on for longer. Or the cash you save in undertaking that energy efficiency action, what do you spend that on? Do you spend that on things which also consume energy?" (EE7)	Energy rebound	*User-owned touchpoint*
"*In the case of buildings with multiple flats, the role of the building manager should be enhanced as it may succeed in creating awareness among owners on the need to implement energy efficient renovations.*" (EE13)	The role of building managers in supporting change	*Brand-owned touchpoint*

Illustrative Quote	Open Coding	Category
"*Only through building regulations have consumers become fairly conscious of what energy is in terms of the insulation of their homes and the movement away potentially from fossil based heating systems [...] we've had maybe 15 years of significant building regulations […] But I think more work needs to be done to enhance efficiency change through regulation change.*" (EE9)	Impact of building regulations	*Partner-owned touch-point*
"*It's necessary to redefine social norms in terms of what's acceptable and responsible energy use [this is shaped by] the behaviour of others that are already familiar with energy efficiency issues.*" (EE14)	Social norms around energy use	*Social/external touch-point*

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Declarations

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